

What is claimed is:

1. An apparatus for measuring viscosity with a micromechanical
5 measuring facility and electronic systems for measuring, transducing and
analyzing signals, with the following features:
a measuring zone implemented on a mechanically stable substrate is
freely accessible or enclosed within a measuring chamber with pores or
openings for diffusive or convective mass transport, the measuring zone
10 containing two or several closely spaced conductors of which at least one is
connected to a controllable current source or HF voltage source and of which at
least one is completely or partially cantilevered within the measuring zone, the
position of the cantilevered conductor(s) being defined within the measuring
zone by the resiliency of the bracket or their/its own resiliency and by voltage-
15 dependent or current-dependent electrical or magnetic attraction or repelling
forces, which can be changed by means of said HF voltage sources or current
sources, and the measuring zone containing an implemented measuring set up
for detection of the viscosity-dependent position change of the conductor(s) in
response to changes of said attraction or repelling forces.
20
2. The apparatus of claim 1, wherein the substrate consists of a
semiconductor material and contains implemented circuits for detecting the
position respectively position change of the cantilevered movable conductor(s)
and/or for the signal transduction and/or the signal export and/or for the
25 controllable current or HF voltage sources.
3. The apparatus of claim 1, wherein a tightly implemented loop or flat coil
and a cantilevered movable conductor forming a loop are arranged on the
substrate at the place of the measuring zone, this cantilevered movable

conductor being fixed to the substrate at two or more points within the measuring zone.

4. The apparatus of claim 1, wherein the substrate is formed as bar-shaped thin tip at the place of the measuring zone.

5. The apparatus of claim 4, wherein the measuring zone is connected with the outer medium by a dialysis membrane, the resulting measuring chamber being filled with a macromolecular sensitive fluid, the components of which cannot penetrate the dialysis membrane and the viscosity of which is determined by reversible affinity bonds between polymer substances and can be changed by the concentration of one or several analyte molecules for which the dialysis membrane is permeable, wherein at any point the sensitive fluid volume being bordered by the dialysis membrane and the substrate is not remote from the dialysis membrane by more than .5 mm.

6. The apparatus of claim 5, wherein the bar-shaped thin tip with the measuring zone is arranged in the lumen of a dialysis hollow fiber but not completely filling out this lumen, so that the region between hollow fiber membrane and substrate acts as a measuring chamber.

7. The apparatus of claim 6, wherein the movable conductor(s) which is (are) cantilevered in the measuring zone consist(s) of thin metal wires and wherein the resilient resistance of the movable conductor(s) against the field-induced force is mainly based on the torsion of said wires.

8. The apparatus of claim 7, wherein the cantilevered movable conductor(s) are arranged in the field of a permanent magnet in such a way, that this field is directed perpendicularly to the movable conductor(s) and to their/its

main direction of movement and wherein the movable conductors are connected to a controllable current source.

9. A method of measuring viscosity with a device according to claim 8,
5 wherein the position change of the cantilevered movable conductor(s) referring to the substrate or one other conductor being induced by a change of the electrical HF field or of the magnetic field intensity and the viscosity dependent velocity or extent of this position change being established by means of a preferably high frequency capacity or impedance measurement or by means of
10 the frequency-shift of an HF-oscillator.

10. The method of measuring viscosity of claim 9, wherein the viscosity-dependent amplitude of the measured position change of the cantilevered movable conductor(s) is evaluated at a suitable modulation or switching
15 frequency of the HF field affecting the conductors or of the current flowing in the conductor(s) or as function of the modulation or switching frequency.

11. The method of measuring viscosity of claim 9, wherein the intensity or direction of the magnetic force or the intensity of the electrostatic force to the
20 cantilevered movable conductor(s) is abruptly changed by the control of the current- or HF voltage source(s) and subsequently the viscosity-dependent position change of the conductors is measured as a function of time.

12. A method of making a device for measuring viscosity according to claims
25 8, wherein after completion of all active and passive components of the viscosity sensor on a suitable semiconductor substrate (including the implemented leading paths) but before separation of the chips jointly generated on the semiconductor substrate (wafer), an additional photolithographically structured soft mask is applied to enable a localized isotrope insulator etching process on the parts of

the upper conducting path layer being provided in the completed sensor as cantilevered movable conductors and wherein these parts of the upper conducting path layer are undercut by etching and completely separated from the corresponding sections of the insulating base in the localized isotrope
5 insulator etching process.

13. The method of claim 12, wherein the intermediate layer between the uppermost conductor path and the lower conductor is dielectric and consists of at least two layers of different chemical compounds, and wherein the lower part of
10 the interlayer is not affected by the etching agent used for the isotropic undercutting of the upper conductor path.

14. The method of claim 13, wherein the upper partial layer of the intermediate layer consists of silicon dioxide or silicate glass and one of the
15 lower partial layers consists of Si_3N_4 .

15. An apparatus for measuring the viscosity of a fluid, comprising:
a substantially rigid support;
an extension protruding from the support and provided with a first
20 conductive path;
a cantilever member comprising a second conductive path extending over the first conductive path and resiliently biased to a first position spaced therefrom;
means for cyclically energizing at least one of the first and second
25 conductive paths for moving the cantilever member to a second position;
means for detecting the rate of return of the cantilever member to its first position to derive a value representative of the viscosity.

16. The apparatus of claim 15, wherein the length and width of the extension

are about 1 mm and 300 μ m, respectively.

17. The apparatus of claim 16, wherein the extension and the cantilever member are mounted in a chamber formed by a membrane of predetermined permeability.

18. The apparatus of claim 17, wherein the membrane is a dialysis membrane and wherein the layout of the chamber is such that the distance between any point in the chamber and a permeable portion of the membrane does not exceed .3 mm.

19. The apparatus of claim 18, wherein the dialysis membrane has a molecular weight cut-off of about 10 kDa.

20. The apparatus of claim 19, wherein the chamber contains lyophilized components of a fluid sensitive to glucose.

21. The apparatus of claim 15, wherein the at least one of the first and second conductive paths is adapted to be energized by direct current.

22. The apparatus of claim 15, wherein the at least one of the first and second conductive paths is adapted to be energized by high frequency voltage.

23. The apparatus of claim 22, wherein the high frequency voltage is in the Ghz range.

24. A method of measuring the viscosity of a fluid, comprising the steps of:
providing a substantially rigid member with a first conductive path therein;
providing a resiliently flexible member having a second conductive path

therein biased into a first position spaced from the first conductive path;
subjecting the rigid and flexible members to the fluid;
energizing at least one of the first and second conductive paths to move
the flexible member to a second position;
5 measuring the rate of movement of the flexible member to derive
therefrom a value representative of the viscosity.

25. The method of claim 24, wherein the at least one conductive path is
energized by high frequency voltage and wherein the rate of movement is
10 measured by the capacitance between the first and second conductive paths.

26. The method of claim 24, wherein the at least one conductive path is
energized by direct current and wherein the rate of movement is measured by
rate of relaxation of the resilient member.
15

27. The method of claim 24, wherein the rigid and resiliently flexible members
are disposed in a measuring chamber formed by a membrane of predetermined
permeability and wherein the chamber further contains a fluid sensitive to the
fluid for measuring the viscosity thereof by affinity.
20

28. A method of fabricating an apparatus for measuring the viscosity of a fluid,
comprising an elongate rigid member extending from a substrate of a
semiconductor material for supporting a first conductive path and a second
member supporting a second conductive path and mounted for oscillations
25 relative to the first member, wherein the second member is formed by depositing
on the parts of the substrate provided with second conductive path an additional
photolithographic lacquer mask for undercutting by localized isotropic insulator
etching.

29. The method of claim 28, wherein an intermediate layer comprising at least two superposed layers of different chemical compounds is provided between the first and second conductive paths and wherein the etching step is performed on an upper one of the layers.

5

30. The method of claim 29, wherein the etching step is performed with an etching agent removing layers of one of silicon dioxide and silicate glass and immune to lower layers of Si_3Ni_4 .

10

15

20

25